

## INDEX

The index covers the two volumes of this manual. Volume I contains pages 1-284 and Volume II contains pages 285-631

### A

A-pach sounding reel, 104  
 Acceleration head, 391,429,439  
 Accuracy of bubble-gage stage recorders, factors affecting, 71-74  
 Accuracy of current-meter discharge measurements, factors affecting, 179-181 standard error, 181-183  
 Accuracy of float measurements of discharge, 262  
 Accuracy of float-operated stage recorders, factors affecting, 68-70  
 Accuracy of nonrecording stage gages, factors affecting, chain gage, 67-68 electric-tape gage, 66-67 float-tape gage, 65-66 staff gage, 64 wire-weight gage, 64-65  
 Accuracy of tracer-dilution discharge measurements, factors affecting, 215-220  
 Acoustic velocity meter, 528-529  
See also Velocity index, acoustic meter  
 Air entrainment, effect on acoustic velocity metering, 456  
 Air line sounding correction for vertical angles, 159-163, 166-168  
 Anchor ice, 361,364-366  
 Angle of current, measurement of, 129-130,142-143  
 Annual published report, discharge records in, 617,618,624,627-630 format of, 601-603 hydrologic-conditions bar graph in, 616 index of, 631 introductory text of, 606-614 list of stations in, 605 map of stations in, 615 reservoir records in, 619-623 revision of published records in, 625 river-basin schematic diagram in, 626 table of contents of, 604  
 Artificial controls  
See Controls, artificial  
 Auxiliary gage, 3,23,53-54,400-405,547  
 Azimuth indicator, 129-130

### B

Backwater, definition of, 393  
 Backwater, variable  
See Variable backwater  
 Backwater from aquatic growth, 6  
 Backwater from ice  
See Ice, effect on stream hydraulics  
See Ice effect, discharge computation for periods of  
 Base gage, 23,53-54,400,547  
 Bed configuration in sand-channel streams, 377-379  
 Bench mark, 24  
 Bends, discharge determination at, in open channels, 281-283 in pipes, 526-527  
 Bernoulli energy equation, 322  
 Boat equipment for current-meter discharge measurement by, conventional method, 120-123 moving boat method, 187-197  
See also Current-meter discharge measurements from boats  
 Boundary effect on, acoustic velocity-meter operation, 454-456,459 surface velocity, 137-138 vertical-axis current-meter operation, 82,87-88  
 Boyer method, 416-418  
 Braystoke current meter, 88  
 Bridge board, 119  
 Bridge equipment for current-meter discharge measurement, 117-120  
See also Current-meter discharge measurements from bridges  
 Bridge piers, 149-150  
 Brine-injection system, 533  
 Bubble-gage stage recorder, accuracy of, factors affecting, 71-74 bubble-feed rate effect on, 72-74 description of sensor for, 32-34 gas column, weight-variation effect on, 74 gas-friction effect on, 71-72 operation of, 60-61 orifice installations for, 33-34,52 shelter for, 51-52

- Cable cars, 110-115  
 pullers for, 111  
 sounding-reel seats for, 111
- Cableway, carrier (bank-operated), 115-117
- Cableway equipment for current-meter discharge measurement, 110-117  
See also Current-meter discharge measurements from cableways
- Canfield sounding reel, 102-104
- Chain gage,  
 accuracy of, factors affecting, 67-68  
 description of, 31-32
- Changing discharge, effect of  
See Unsteady flow
- Channel control,  
See Controls, channel
- Coaxial rating-curve method, 481-484
- Colorimetric analysis, 249-250
- Columbus-type control, 312
- Columbus weights, 102
- Conductance meter, 252-255
- Connectors in current-meter assembly, 102
- Constant rating-fall method, 396-400
- Contracted-opening method of peak-discharge determination, 277-279
- Controls,  
 attributes desired in, 11-12, 15-16  
 sensitivity of, 12  
 stability of, 11-12  
 types of, 10-11
- Controls, artificial,  
 attributes desired in, 12, 15-16  
 choice of, 17-20  
 definition of, 10  
 design of, 21-22  
 for sand channels, 387-388  
 precalibration of, 16-17, 21, 260  
 purpose of, 3  
 types of, 12-13  
See also Stage-discharge relation, artificial controls  
See also Shifting control
- Controls, channel  
 definition of, 10, 286-287  
 rating for, 328-332, 382-385  
 rating shifts for, 354-360, 385-387
- Controls, complete, definition of, 10
- Controls, compound, definition, 10
- Controls, natural  
 attributes desired in, 11-12  
 definition of, 10
- See also Stage-discharge relation, natural controls
- Controls, partial, definition of, 11
- Controls, section, definition of, 10, 286-287  
See also Stage-discharge relation, artificial controls  
See also Stage-discharge relation, natural controls  
See also Shifting control
- Conversion factors, XIV
- Conveyance-slope method, 334-337
- Counter, electric, for current meter, 130
- Cranes for current-meter measurements, 117-120
- Crest-stage gages,  
 description of, 77-78  
 location of, 9
- Crump weir, 307
- Cubatures, method of, 476-479
- Culvert discharge,  
 characteristics of, 281  
 determination of, 279-280  
 types of, 281, 282
- Current angularity, measurement of, 142-143
- Current-direction indicator, 129-130
- Current meter, conventional,  
 care of, 93-94  
 comparison of performance of vertical-axis and horizontal-axis types of, 89-90  
 principle of operation of, 84  
 rating of, 94-96  
 types of, 85  
See also Velocity index, standard current meter
- Current meter, horizontal-axis,  
 Braystoke meter, 88  
 comparison with vertical-axis meter, 89-90  
 Haskell meter, 88-89  
 Hoff meter, 88-89  
 Neypric meter, 88-89  
 Ott meter, 88-90, 142
- Current meter, optical,  
 care of, 94  
 characteristics of, 91-93  
 rating of, 96-97  
 use of, 137, 170, 175, 270
- Current meter, vertical axis,  
 comparison with horizontal-axis meter, 89-90  
 performance characteristics, 87-88  
 Price AA meter, 85-88, 88-90, 143-145  
 Price pygmy meter, 86, 143-145  
 USGS vane meter, 86-87, 154
- Current-meter discharge measurement,  
 description, general, 80-82  
 general information to be recorded, 140-141

mean-section method, 82  
 measurement of horizontal  
     angle of flow, 142-143  
 measurement notes, 83  
 midsection method, 80-82  
 observations to be recorded,  
     141-142  
 precautions in subfreezing  
     weather, 148  
 precautions when debris is  
     present, 148  
 preparation of equipment, 141  
 procedure, general, 139-143  
 selection of cross section,  
     7, 139-140, 149, 151, 153  
 selection of observation  
     verticals, 140, 149, 153,  
     174, 175  
 sounding correction for  
     vertical angles, 159-168  
 standard error, 181-183  
 storage correction, 177-179  
 summary of factors affecting  
     accuracy, 179-181  
 velocity determination, 131-  
     139  
     See also Velocity measurements  
 Current-meter discharge measure-  
     ments from boats, con-  
     ventional method,  
     equipment assembly for, 120-  
     123  
     limiting factors, 155, 157-158  
     position of boat for obser-  
     vations during, 156-157  
     procedure for, 158  
     stringing of tag line for, 155  
     See also Discharge measure-  
     ments by moving-boat  
     method  
 Current-meter discharge measure-  
     ments from bridges,  
     choice of upstream or down-  
     stream side of bridge, 149  
     depth corrections for deep,  
     swift streams, 159-168  
     equipment assembly for, 117-  
     120  
     footbridge and rod suspension,  
     use of, 150  
     handline, use of, 150-151  
     meter-setting, computation  
     for, 147  
     piers in measurement section,  
     82, 149-150  
     procedure, general, 149-151  
     sounding weight, selection of,  
     146-147  
     tags for meter setting, use  
     of, 147-148  
     velocity-observation method,  
     selection of, 147, 148  
 Current-meter discharge measure-  
     ments from cableways,  
     depth correction for deep,  
     swift streams, 159-168  
     equipment assembly for, 110-  
     117  
     handline, use of, 150-151  
     meter-setting, computation  
     for, 147  
     procedure, general, 146-148  
     sounding weight, selection of,  
     146-147  
     tags for meter setting, use  
     of, 147-148  
     velocity-observation method,  
     selection of, 147, 148  
 Current-meter discharge measure-  
     ments of deep, swift  
     streams,  
     when depth can be sounded,  
     159-168  
     when depth cannot be sounded,  
     168-169  
     when meter cannot be  
     submerged, 170  
 Current-meter discharge measure-  
     ments from ice cover,  
     effective depth, measurement  
     of, 153-154  
     equipment assembly, 124-129  
     measurement cross section,  
     selection of, 151, 153  
     measurement notes, 155, 156  
     meter setting, 153, 155  
     observation holes, number of,  
     153  
     partial ice cover, method used  
     for, 155  
     precautions, 151, 155  
     procedure, general, 151-155  
     vane meter, use of, 154  
     vertical-velocity distri-  
     bution, 154  
 Current-meter discharge measure-  
     ments, mean gage height  
     of,  
     discharge-weighted mean, 171-  
     173  
     frequency of gage-height  
     readings, 170-171  
     time-weighted mean, 171, 173  
 Current-meter discharge measure-  
     ments, procedures for,  
     during rapidly changing  
     stage  
     on large streams, 174-175  
     below powerplants, 140  
     on small streams, 174, 175-177  
 Current-meter discharge measure-  
     ments, types of  
     boat, 155-158  
     See also Discharge  
     measurements, moving-  
     boat method  
     bridge, 149-151  
     cableway, 146-148  
     ice cover, 151-155  
     network of meters, 158-159  
     wading, 143-146  
 Current-meter discharge measure-  
     ments by wading,  
     cross section, modification  
     of, 144-146  
     current-meter type, selection  
     of, 143-144, 145  
     position of hydrographer, 146

procedure, general, 143-146  
 velocity-observation method,  
     selection of, 143,145  
 zero flow, gage height of, 146

D

Dams  
     inflatable, 510-511  
     See also Weirs  
 Dams with movable gates, 486-488  
     See also Gates  
 Datum,  
     definition of, 23  
     maintenance of, 23-24,63-64  
 Datum corrections, 545-583  
     level notes for, 545-546  
 Deflection meter  
     See Velocity index, deflection  
     meter  
 Depth corrections for deep,  
     swift streams,  
     meter-position correction,  
     167-168  
     tags, use of, 147-148,150,  
     160,163  
     total-depth correction, 159-  
     167  
 Depth, measurement of,  
     handline method, 150-151  
     rod method, 97-101,150  
     sonic-sounder method, 108-110  
     sounding-reel method, 147-  
     148,159-167  
     under ice, 153-154  
     See also Sounding equipment  
 Differential-head meter, 522-528  
 Digital stage recorder, 36-39  
     servicing of, 59-60,63  
 Direction of current, 129-130,  
     142-143  
 Discharge, changing  
     See Unsteady flow  
 Discharge, defined, 79,273-274  
 Discharge measurements,  
     below hydroelectric power-  
     plants, 140  
     correction for storage, 177-  
     179  
     frequency of, 79  
     listing of, 287-288,547-549  
     mean gage height of, 170-173  
     See also Current-meter  
     discharge measurements,  
     mean gage height of  
     plotting of, 287  
     review of, 547-549  
 Discharge measurements by con-  
     ventional current meter  
     See Current-meter discharge  
     measurements  
 Discharge measurements by float  
     method, 170,261-262  
     accuracy of, 262  
 Discharge measurements by  
     fluorescent-dye dilution,  
     discharge, computation of,  
     240-246  
     mean velocity adjustment,  
     208-210  
     total width and area  
     adjustment, 207-208  
     unadjusted discharge, 204-  
     207  
     discharge-computation notes,  
     244  
     field procedures, 237-240  
     fluorometer analysis, 240-241  
     sample computation, 241-246  
     simplified procedures for  
     making numerous measure-  
     ments, 246-248  
 Discharge measurements by  
     moving-boat method,  
     angle observer, function of,  
     202  
     battery charger, 193  
     boat, 195-196  
     boat operator, function of,  
     201-202  
     current meter, 188-189  
     description, general, of  
     measurement method, 183-  
     184  
     discharge, computation of,  
     204-211  
     equipment,  
         assembly of, 199-200  
         mounting of, 195-197  
         removal of, 197  
     field procedures, 197-204  
     instrument setting,  
         for rate indicator, 201  
         for sonic sounder, 200  
     measurement notes, 206  
     measurement site, preparation  
     of, 197-198  
     notekeeper, function of, 203-  
     204  
     rate indicator and counter,  
     190-193  
     sonic sounder, 193-195  
     theory of measurement method,  
     184-187  
     vane and angle indicator, 187-  
     188  
 Discharge measurements by radio-  
     active-tracer dilution,  
     256-258  
     radioactive tracers, 212,257  
 Discharge measurements by salt  
     dilution,  
     advantages of, 212,237,250  
     concentrated solution,  
     preparation of, 251-252  
     discharge, computation of,  
     255-256  
     injection of concentrated  
     solution, 252  
     measurement notes, 256  
     measurement reach, selection  
     of, 251  
     sampling by conductance meter,  
     252-255  
 Discharge measurements by  
     sodium dichromate  
     dilution, 212,249-250

Discharge measurements by timing  
drift, 170,261-262

Discharge measurements by tracer  
dilution, constant-rate  
injection,  
advantages of, 212,219,237  
concentration-time curve,  
213,214  
fluorescent dye, use of, 223-  
248  
sodium dichromate, use of,  
249-250  
theory, 212,213

Discharge measurements by tracer  
dilution, general,  
calibration of measurement  
reach, 220-222  
inflow or outflow, effect of,  
222-223  
loss of tracer, 216,239  
mixing length, 217-219  
mixing of tracer in reach,  
216-219  
percentage of mixing, 219-220  
tracer criteria, 211-212  
turbidity, effect on, 215-216  
when used, 212

Discharge measurements by tracer  
dilution, sudden  
injection,  
advantages of, 212  
concentration-time curve, 214-  
215  
radioactive tracers, use of,  
212,256-258  
salt, use of, 212,250-256  
theory, 212-213,214-215  
See also Dye-injection  
apparatus, fluorescent  
dye, fluorometer

Discharge measurements, types  
of,  
current-meter (conventional)  
method, 79-183  
float method, 261-262  
moving-boat method, 183-211  
peak discharge, indirect  
methods for, 273-284  
portable Parshall flume  
method, 265-267  
portable-weir method, 263-265  
tracer-dilution method, 211-  
259  
unstable flow, method for,  
268-272  
volumetric method, 262-263

Discharge rating for hydraulic  
facilities, 486-543  
See also Stage-discharge  
relation

Discharge-record, daily,  
digital-recorder station,  
automated-computation sequence  
for, 592-597  
computation-progress form for,  
597,599-600  
general procedure for, 587  
input to computer for, 588,589

output from computer for,  
588,590-592  
station-analysis document  
for, 597,599

Discharge record, daily,  
estimates for  
periods of indeterminate  
stage-discharge relation,  
572-573  
periods of no gage-height  
record, 573-579

Discharge record, daily,  
graphic-recorder station,  
computation form for, 569-  
571,579-580  
computation method for, 571-  
572  
computation procedure for 3-  
parameter discharge rela-  
tion, 586-587  
computation-progress form for,  
580  
station-analysis document for,  
580-585  
tabulation form for, 570

Discharge record, daily,  
nonrecording station, 559-  
560

Discharge records, daily,  
hydrographic comparison  
of, 572-573,575-576

Discharge relation, three-  
parameter, 558-559,586

Drift, discharge measurement by  
timing, 261-262

Dry-line sounding correction for  
vertical angles, 159-  
162,163,166-168

Dye  
See Fluorescent dye

Dye-injection apparatus,  
floating siphon, 233-234  
Mariotte vessel, 232-233  
pressure tank, 234-235

E

Earth Resources Technology  
Satellite (ERTS), 57-59

Electric heaters in stilling  
wells, 48

Electric-tape gage,  
accuracy of, factors  
affecting, 66-67  
description of, 28,30

Electromagnetic velocity meter  
for,  
open channels, 528  
See also Velocity index,  
electromagnetic meter  
pressure conduits, 528

Equipment assemblies for  
current-meter discharge  
measurements,  
boat equipment, conventional,  
120-123  
bridge equipment, 117-120

cableway equipment, 110-117  
 ice equipment, 124-129  
 moving-boat equipment, 187-197  
 velocity-azimuth-depth  
   assembly, 129-130

F

Fall, 393,394-395  
 Fall-rating method  
   See Stage-fall-discharge  
   relation  
 Float measurement of velocity,  
   260-262  
   accuracy of, 262  
 Float-operated stage recorder,  
   effect on accuracy of,  
   counterweight submergence, 69-  
   70  
   float lag, 68-69  
   line shift, 69  
   temperature change, 70  
 Float sensor, description of, 32  
 Float-tape gage,  
   accuracy of, factors  
   affecting, 65-66  
   description of, 26,28  
 Flood routing, 344  
 Flood wave, velocity of, 415  
 Flume,  
   choice of, 17-20  
   design of, 21-22  
   types of, 13,312-314  
   use of for a control, 12-13  
 Flume, critical-flow, choice of,  
   20  
   See also Parshall flume  
 Flume, portable, 265-267  
 Flume ratings, shifts in, 351-  
   352  
 Flume, supercritical-flow type,  
   choice of, 20  
   description of, 320-322  
   ratings for, 322-326  
 Fluorescence, defined, 223  
 Fluorescent dye,  
   calibration of standard  
   solutions of, 228-230  
   characteristics of, 223  
 Fluorescein, 223  
   quantity for constant-rate  
   injection of, 235-236  
   quantity for sudden injection  
   of, 236-237  
 Rhodamine B, 223  
 Rhodamine BA, 223  
 Rhodamine WT, 223  
   sensitivity of measurement of,  
   212,223  
   storage of, 230  
   See also Discharge measure-  
   ments by tracer dilution,  
   constant-rate injection  
 Fluorometer, 212,223-232  
   background samples for, 231,  
   240-241  
   calibration characteristics  
   of, 226-228

description of, 223-226  
 effect of temperature changes  
   on, 226-228,240  
 field use of, 225-226  
 operation of, 231-232  
 precautions in use of, 229,  
   231-232,238,239-240  
 Frazil ice, 360-361  
 Froude number, 549

G

Gage  
   See Stage gage  
 Gage datum  
   See Datum  
 Gage height,  
   definition of, 22-23  
   documentation of record, 583  
   indicator of minimum, 61  
   indicator of peak, 39,60-61  
   mean for discharge measure-  
   ment, 170-173  
   See also Current-meter  
   discharge measurements,  
   mean gage height of  
   zero flow, 23,146,291,333-334,  
   549  
 Gage-height record, digital  
   recorder, 588-592  
 Gage-height record, graphic  
   recorder,  
   computation method for, 560-  
   569  
   determination of daily mean  
   gage height from, 564  
   gage-height corrections for,  
   563-564  
   subdivision of daily gage  
   heights from, 564-569  
   time corrections for, 560-562  
 Gage-height record, nonrecording  
   station, 24-25  
   computation method for, 559-  
   560  
 Gage-height record, uses of, 23  
 Gage well  
   See Stilling well  
 Gaging cars  
   See Cable cars  
 Gaging station  
   See Stream-gaging station  
 Gates,  
   bear trap, 509,511-512  
   discharge rating of, 536-538  
   drum, 488-496  
   flashboards, 512-513  
   hinged-leaf, 509,511-512  
   needles, 514  
   radial,  
   on curved dam crest or  
   still, 496,499-507  
   on horizontal surface, 496-  
   499  
   roller, 508  
   stop logs, 514  
   Tainter (See radial)

vertical-lift, 507-508  
wickets, 509-510,511-512  
Geiger counter, 258  
Gibson method, 533-536  
Graphic stage recorder, 39-41  
servicing of, 59-60,63  
See also Stage gage, recording

## H

Handline, sounding,  
description of, 104,106-108  
use of, 150-151  
Haskell current meter, 88,89  
Headphones for counting meter  
revolutions, 130  
Heaters for stilling wells, 48  
High-water marks,  
at crest-stage gage, 77-78  
at stream-gaging stations, 60-  
61  
Hoff current meter, 88,89  
Horizontal-axis current meters,  
88-90  
Horizontal-axis deflection vane,  
435-437  
Hydraulic facilities  
dams with gates, 436-514  
navigation locks, 514-515  
Hydroelectric powerplants,  
discharge measurements below,  
140  
discharge ratings for, 536-  
538  
Hydrographic comparison of daily  
discharge records,  
572,575-576

## I

Ice, consideration of, in  
gaging-station site  
selection, 8  
Ice, discharge measurement from,  
151-155  
Ice, effect on shifts, 553-554  
Ice, effect on stream hydraulics  
description of, 360  
from anchor ice, 361  
from frazil, 361  
from surface ice, 363-364  
Ice, formation  
of anchor ice, 361  
of frazil, 360-361  
of surface ice, 362-363  
Ice cover, effect on tracer  
mixing, 216  
Ice creepers, 131  
Ice effect, discharge compu-  
tations for periods of,  
anchor ice, 364-366  
discharge-ratio method, 368-  
369  
hydrographic- and climatic-  
comparison method,  
368,370-375

proposed method, 375-376  
shifting-control method,  
368,369-370  
surface ice, 366-376  
Ice equipment,  
ice chisel, 125  
ice drill, 124-125  
ice-measuring stick, 125-128  
reel support, collapsible, 128  
weight assembly, 128-129  
See also Current-meter  
discharge measurements  
from ice cover  
Ice in measurement section,  
effect on accuracy, 180  
Inclined staff gage, 26,64  
Indirect determination of peak  
discharge, 2,273-284  
See also Peak discharge,  
indirect determination of  
Inflatable dams, 510  
Instrument shelters for stage  
recorders, 51-52  
Intakes for stilling wells,  
drawdown at, 47  
flushing system for, 44,50  
lag of, 45-47,60  
location of, 8, 43-44  
static tubes for, 47,50

## J

Jones method, 416

## L

Laboratory rating of controls,  
16-17,21,260  
Laser flowmeter, 529  
Leveling, checking of gages by,  
545-546  
Lewis method, 416  
Locks, navigation,  
leakage through, 515-520  
lockage discharge, 514-515  
Logarithmic plotting, 289-294  
Loop rating curve  
for rigid-boundary channels,  
390,413-414  
for sand channels, 378-379

## M

Manning equation, 274-277,  
329,342  
Mariotte vessel, 232-233  
Maximum-stage indicator, 39,60-  
61  
Measurement section, selection  
of, 7,139-140,149,151-153  
Mechanical meters, 521-522  
Meters, pipe,  
bend, 526-527

displacement, 521  
flow-nozzle, 525-526  
inferential, 521-522  
orifice, 526  
unaltered-conduit, 527  
variable-area, 522  
venturi, 522-525  
Minimum-stage indicator, 61  
Model T stage recorder, 74-75  
Motion of current meter, effect  
of, 180-181  
Moving-boat discharge-  
measurement method  
See Discharge measurement,  
moving-boat method  
Moving-boat equipment assembly,  
187-197

#### N

Neypric current meter, 88-90  
Nonrecording gage  
See Stage gage, nonrecording

#### O

Observer for gaging station, 24-  
25  
Oil for prevention of freezing  
in,  
bubble-gage vent pipe, 33-34  
stilling wells, 48,51,60,66-67  
Open-water discharge, 368  
Optical current meter  
See Current meter, optical  
OTT current meter, 88-90  
Orifice flow  
free, 501-503  
submerged, 503-505

#### P

Palmer-Bowlus flume, 538  
Parshall flume,  
portable, 260,265-267  
standard,  
description of, 314-316  
ratings for, 316-317  
Partial-record stations, purpose  
of, 3  
Peak discharge, indirect  
determination of,  
bend-superelevation method,  
218,283  
contracted-opening method,  
277-279  
culvert-discharge method, 279-  
281,282  
dam-discharge method, 279  
factors in, 273-274  
field data for, 274  
slope-area method, 274-277  
weir-discharge method, 279  
Peak-runoff comparison, 337-338  
Peak-stage indicator, 39,60-61

Piers in discharge-measurement  
section, 82,149-150,179  
Pipe meters  
See Meters, pipe  
See Pressure-conduit metering  
Pitometer, 529-532  
Pitot-static tube, 529-532  
Portable flume, 265-267  
Portable weir, 263-265  
Pressure-conduit metering by,  
acoustic-velocity meter, 528-  
529  
differential-head meter, 522-  
528  
electromagnetic-velocity  
meter, 528  
laser flowmeter, 529  
mechanical meters, 521-522  
See also Meters, pipe  
Pressure-conduit meter rating  
by,  
Gibson method, 533-536  
pitometer, 529-532  
pitot-static tube, 529-532  
salt-velocity method, 533  
Price current meter,  
pygmy, 86-88,143-145  
standard, 85-90,143-145  
Protractor, measurement of cable  
angle, 118-119  
Published reports  
See Annual published reports  
Pulsating flow  
See Unstable flow  
Pulsations, horizontal, during  
discharge measurements,  
84-85  
Pulsations, vertical, in holes  
cut through ice, 153,155  
Pumps, discharge rating of, 536-  
537  
Pygmy current meter, 86,87-88,  
143-145

#### R

Radial gate flow-over, 506  
Radioactive tracers, 212,256-258  
See also Discharge measure-  
ments by radioactive  
tracer dilution  
Rating  
See Stage-discharge relation  
Rating curve,  
analysis of, 550-555  
extrapolation of, 332-344  
graphical plotting of, 287-294  
"e" value determination,  
289-293  
preparation of, 549-550,559  
Rating-fall method  
See Stage-fall-discharge  
relation  
Rating table,  
expanded, 557  
preparation of, 555-559  
standard, 556

Recording stage gage  
   See Stage gage, recording  
 Rectangular-coordinate plotting,  
   294,333-334  
 Reel  
   for sounding line, 102-104  
   for width-measurement tag  
   line, 110,111,120-121  
 Reference gage, 53-54  
   inside gage, 53  
   outside gage, 53  
   See also Base gage  
 Reference mark, 24,54  
 Reference point, 54  
 Relative concentration, 228  
 Reversal errors, for graphic  
   recorders, 563  
 Roll waves  
   See Unstable flow  
 Roller gates, 508  
 Roughness coefficient, selection  
   of, 274,342,347,549

S

Salt (NaCl), 212,237,250  
   See also Discharge measure-  
   ments by salt dilution  
 Salt-velocity measurement in  
   pressure conduits, 533  
 Sand-channel streams,  
   bed configurations for, 377-  
   379  
   depth-discharge relation for,  
   379-382  
   evidence of bed forms in, 384-  
   385  
   flow regime of, 377-379  
   sites for gaging stations on,  
   377  
   stage-discharge relation for,  
   376-377,382-384,385-387  
 Sand-channel streams, current-  
   meter measurements of,  
   observation of configuration  
   of streambed and water  
   surface, 146  
   position of stream gager, 146  
 Sand-channel streams, gaging  
   stations on,  
   artificial controls for, 22,  
   387-388  
   sites for, 6,377  
   use of bubble gage for, 33-34  
 Satellite data-collection  
   system, 57-59  
 Scintillation counter, 258  
 Section control  
   See Controls, section  
 Section-control ratings  
   See Stage-discharge relation,  
   artificial controls  
   See Stage-discharge relation,  
   natural controls  
   See Shifting control  
 Seddon principle of wave  
   velocity, 415

Sediment, inclusion of, in  
   measured discharge, 273-  
   274  
 Sediment concentration, effect  
   on,  
   acoustic-velocity metering,  
   456-457  
   sand-bed configuration, 377-  
   378  
 Sediment trap for stilling well,  
   51  
 Sedimentation effect on,  
   channel-control ratings, 354-  
   359  
   flume ratings, 351-352  
   natural section-control  
   ratings, 352  
   weir ratings, 348-350  
 Servo control, 32  
 Servomanometer, 32  
 Sewer flowmeter,  
   USGS-type, 538-541  
   Wenzel, 541-542  
 Shifting control, 344-345  
   channel-control ratings, 354-  
   360,385-387  
   detection of rating shifts,  
   345-348  
   flume ratings, 351-352  
   natural section-control  
   ratings, 352-353  
   sand-channel ratings, 385-387  
   stage-fall-discharge ratings,  
   422-423  
   weir ratings, 348-351  
 Shifts, application to rating  
   curves, 553-554  
 Slope-area determination of peak  
   discharge, 274-277  
 Slope stations, 390-412  
   criteria for establishment,  
   390-391  
   proposed analysis method, 423-  
   425  
   theoretical considerations,  
   391-392  
   variation from true slope,  
   394-395  
   See also Stage-fall-discharge  
   relation  
 Slug flow  
   See Unstable flow  
 Sodium dichromate, 212,249-250  
 Sonic sounder, 108-110,193-195,  
   200-201  
 Sounding equipment,  
   handline, 104,106-108,150-151  
   reel, 102-104  
   sonic sounder, 108-110,193-  
   195,200-201  
   wading rod, 97-101  
   weights and accessories, 101-  
   102  
 Sounding weights  
   See Weights, sounding  
 SR stage recorder, 76-77  
 Staff gage,  
   as auxiliary gage, 53

Staff gage, vertical and inclined,  
accuracy of, factors affecting, 64  
description of, 26,27  
Stage, definition of, 22  
See also Gage height  
Stage-discharge relation, defined, 79  
discharge measurements required, 285  
extrapolation of high flow, 285-286,334-344  
by conveyance-slope method, 334-337  
by flood routing, 344  
by peak-runoff comparison, 337-338  
by step-backwater method, 338-344  
extrapolation of low flow, 333-334  
graphical analysis, 287-294  
See also Ice effect  
See also Logarithmic plotting  
See also Rectangular-coordinate plotting  
Stage-discharge relation, artificial controls  
flumes, 294-295,312-314  
See also Flume, supercritical-flow type  
See also Parshall flume  
general description of, 286-287  
transferrability of laboratory ratings, 295  
weirs, broad-crested, 295,306-307  
See also Columbus-type control  
See also Crump weir  
See also Trenton-type control  
See also Weir, rectangular flat-crested  
See also Weir, rectangular flat-crested, notched  
weirs, thin-plate, 294-306  
See also Weir, rectangular thin-plate  
See also Weir, submerged thin-plate  
See also Weir, trapezoidal thin-plate  
See also Weir, triangular thin-plate  
Stage-discharge relation, natural controls,  
channel control, 328-332,382-384,385-387  
general description of, 286-287  
section control, complete, 326-327  
section control, compound, 327-328  
See also Shifting control  
Stage-discharge relation, sand channels, 376-377,382-384,385-387  
Stage-discharge relation, shifts in  
See Shifting control  
Stage-discharge relation, tidal streams  
See Tidal streams, discharge rating of  
Stage-fall-discharge relation, 392-413,479  
discharge determination from, 412-413  
intermittence of, 396,402,405-408  
rating fall constant, 396-400  
rating fall variable, 400-412  
shift in rating, 422-423  
types of, 395-396  
variable backwater combined with changing discharge, 421-422  
variable slope caused by changing discharge, 413-421  
variable slope caused by variable backwater, 392-396  
See also Slope stations  
Stage gage, nonrecording, advantages of, 23  
reports of readings of, 24-25  
types of,  
chain, 31-32  
electric tape, 28-30  
float tape, 26,29  
staff, 26,27  
wire weight, 26,28  
Stage gage, recording, advantages of, 23  
instrument shelters for, 51-52  
intakes for, 43-47  
See also Intakes for stilling wells  
model T, 74-75  
SR model, 76-77  
types of recorder,  
digital, 36-39  
graphic, 39-41  
types of sensor,  
bubble gage, 32-34  
See also Bubble-gage stage recorder  
float, 32  
See also Float-operated stage recorder  
Stage-velocity-discharge relation,  
acoustic velocity-meter method, 439-459  
deflection-meter method, 432-439  
electromagnetic velocity-meter method, 459-469  
standard current-meter method, 430-432  
velocity index, types of, 429-430

- Static tubes for intakes, 47,50  
 Station analysis, 544-559  
   documentation of, 580-588,  
   597,599  
 Step-backwater method, 338-344  
 Stilling well,  
   auxiliary and reference gages  
   for, 51,53-54,287  
   dimensions of, 42  
   intakes for, 43-47  
   prevention of freezing in, 47-  
   48,51  
   sediment trap for, 51  
   types of, 41  
 Stopwatch for discharge measure-  
 ments, 130  
 Storage corrections for dis-  
 charge measurements, 177-  
 179  
 Storm-drain metering  
   See Urban storm-drain metering  
 Streamflow, defined  
   See Discharge, defined  
 Streamflow records,  
   general, 2-3  
   processing,  
     by digital computer, 2  
     of digital stage record,  
     544-559,587-600  
     of graphic stage record,  
     544-559,560-587  
     of nonrecording stage  
     record, 544-558,559-560,  
     569-587  
 Stream gaging, sand channels  
   See Sand-channel streams,  
   current-meter measurements  
   See Sand-channel streams,  
   gaging stations on  
 Stream-gaging procedures,  
   general, 3-4  
 Stream-gaging stations,  
   nonrecording, 24  
   recording, 32,59-79  
 Stream-gaging station location,  
   field reconnaissance, 6  
   general site selection, 4-5  
   specific site selection, 4-  
   9,12  
 Stream-gaging station network,  
   design of, 4  
   purpose of, 3  
 Stream-gaging station operation,  
   determination of peak stages,  
   60-61  
   frequency of visits, 59  
   inspection and servicing  
   equipment and stage  
   record, 59-60,61-63  
   maintenance operations, 63  
   observer, 25  
 Strip-chart, 59-60  
   See also Graphic stage  
   recorder  
 Subfloors in stilling wells, 47-  
 48  
 Submerged broad-crested weirs,  
   312  
 Submerged thin plate weirs, 305  
   306
- T
- Tag lines (width measurement),  
 110,120-121  
 reels, 110  
 Tags on sounding line, use of,  
 107,147-148,150,160,163  
 Telemark, 55-56  
 Telemetering, 23,54-59  
   impulse system of, 55  
   position-motor system of, 55  
   resistance-system of, 57  
   satellite data-collection  
   system of, 57-59  
 Telemark system of, 55-56  
 Temperature effect on,  
   acoustic-velocity metering,  
   454  
   current-meter measurement  
   accuracy, 180  
   float-operated stage  
   recorder, 70  
   fluorometer analysis,  
   226,227,240  
   sand-bed configuration, 378  
 Tidal streams, discharge rating  
   of,  
   calibration of relation, 471  
   empirical methods, 475-484  
   unsteady-flow equation  
   methods, 471-475  
   variable control, 392  
   velocity-index method, 471  
 Tidal streams, methods for  
 computing discharge, 2  
 Tide-correction method, 479-481  
 Timers for stage recorders,  
 34,37-39,59-60,473  
 Timing drift, discharge measure-  
 ment by, 261-262  
 Tracer dilution,  
   concentration, 228  
   relative concentration, 228  
 Tracer dilution, measurement of  
 discharge by  
   See Discharge measurements by  
   tracer dilution  
 Tracers  
   See Fluorescent dye  
   See Radioactive tracers  
   See Salt  
   See Sodium dichromate  
 Trenton-type control, 311-312  
 Turbines, discharge rating of,  
 536-537  
 Turbulence, 84-85
- U
- Unit rating-fall method, 396-400  
 Unstable flow,  
   description of, 260,268-269  
   examples of, 270-272

method of discharge determination during, 269-270  
 proposed instrumentation for measurement of, 272  
 Unsteady flow,  
   effect on stage-discharge relation, 390,413-428  
   loop rating curve of, 413-414  
   rating-adjustment methods for, 416-421  
     Boyer method, 416-418  
     Jones method, 416  
     Lewis method, 416  
     Wiggins method, 418-421  
   theoretical considerations, 414-416  
 Unsteady flow combined with variable backwater, 421-422  
 Unsteady-flow equations, method of solution,  
   characteristics method, 474-475  
   Fourier series, 475  
   implicit method, 475  
   power series, 473-474  
 Urban storm-drain metering by, 538-542  
   USGS sewer flowmeter, 539-541  
   Wenzel asymmetrical flowmeter, 541-542  
   Wenzel symmetrical flowmeter, 541-542

V

Valves, discharge rating of, 536-538  
 Vane current meter, 86-87,154  
 Variable backwater,  
   discharge determination, 412-413  
   effect on stage-discharge relation, 390,392-413  
   influence on stage-gage location, 7-8  
   rating fall, constant, 396-400  
   rating fall, variable, 400-412  
 Variable backwater combined with changing discharge, 421-422  
 Variable rating-fall method, 400-412  
 Variable slope, 390  
   See also Variable backwater  
 Vegetation, effect on,  
   acoustic-velocity metering, 457,459  
   channel-control ratings, 359-360  
   flume ratings, 351-352  
   natural section-control ratings, 353  
   weir ratings, 350-351  
 Velocity, wave, 415  
 Velocity area method of discharge determination, 334  
 Velocity-azimuth-depth assembly, 129-130  
 Velocity distribution in a vertical  
   under ice cover, 154-155  
   in open water, 132-133  
 Velocity index, acoustic meter, description, 439-441  
   effect of orientation on, 448-454  
   effect of tidal-flow reversal on, 448  
   factors affecting operation of, 454-459  
   in pressure conduits, 528-529  
   theory, 441-448  
   use of for tidal streams, 471  
 Velocity index, deflection meter,  
   examples of use of, 437-439,471  
   horizontal-axis vane, 435-437  
   location of, 432  
   vertical-axis vane, 432-435  
 Velocity index, electromagnetic meter,  
   integrated-velocity index, appraisal of method, 468  
   instrumentation, 465-468  
   theory of, 464-465  
   point-velocity index, analysis of data, 461-464  
   instrumentation, 460-461  
   use of for tidal streams, 471  
 Velocity-index, standard current meter,  
   discharge relation, calibration of, 430-431  
   location of, 430  
   operation of, 430,432  
 Velocity measurement, mean in a vertical by,  
   five-point method, 138  
   integration method, 138  
   six-point method, 138-139  
   six-tenths depth method, 134-135,174,175  
   subsurface-velocity method, 108,136-137,169,174,208-211  
   surface-velocity method, 137-138,175  
   three-point method, 135  
   two-point method, 134  
   two-tenths depth method, 108,135-136,169,174,175  
   vertical-velocity curve method, 132-133  
 Velocity near vertical wall, 82,87,137-138  
 Velocity pulsations, 84-85  
 Venturi flume  
   See Parshall flume  
 Venturi meter, 522-525  
 Vertical-axis current meter  
   See Current meter, vertical axis

Vertical-axis deflection vane,  
     432-435  
 Vertical lift gates, 507-508  
 Vertical staff gage, 26,27,64  
 Vertical velocity curve, 133  
 Verticals, spacing of, in  
     current-meter discharge  
     measurements, 140,149,  
     153,174,175  
 Volumetric measurement of  
     discharge, 260,262-263

W

Wading measurement of discharge  
     See Current-meter discharge  
     measurements by wading  
 Wading rod,  
     ice, 100-101  
     round, 97,99,100  
     top-setting, 97,98  
 Water-stage recorder  
     See Stage gage, recording  
 Water year, 544  
 Wave velocity, 415  
 Weights, sounding,  
     hangers for, 102  
     hanger pins for, 102  
 Weir, rectangular flat-crested,  
     307-308  
     notched, 309-311  
 Weir, rectangular thin-plate,  
     graphical rating analysis of,  
     299  
     theoretical rating analysis  
     of, 295-299  
 Weir, trapezoidal thin-plate,  
     299-302-303  
 Weir, triangular or V-notch  
     thin-plate, 303-305

See also Columbus-type control  
See also Trenton-type control  
 weirs,  
     broadcrested, 12  
     submerged, 312  
     choice between flumes and, 18-  
     20  
     computations of peak discharge  
     over, 279  
     design of, 21-22  
     thin-plate, 12-13  
     submerged, 305-306  
 Weir flow  
     free, 505-506  
     submerged, 506  
 Weir plate, portable, 260,263-  
     265  
     ratings, shifts in, 348-351  
 Wenzel flowmeter, 541-542  
 Wet-line sounding correction for  
     vertical angles, 159,160,  
     163-168  
 Width-measuring equipment, 110  
 Wiggins method, 418-421  
 Wind effect on,  
     chain-gage readings, 68  
     current-meter discharge  
     measurements, 180-181  
     staff-gage readings, 64  
     wire-weight gage readings,  
     65  
 Wire-weight gage,  
     accuracy of, factors  
     affecting, 64-65  
     as auxiliary gage, 53  
     description of, 26,28

Z

Zero flow, 23,146,291-292,333-  
     334,549-550

Volume 1, p. 1-284  
 Volume 2, p. 285-631